Fungal Biomineralization of Manganese as a Novel Source of Electrochemical Materials

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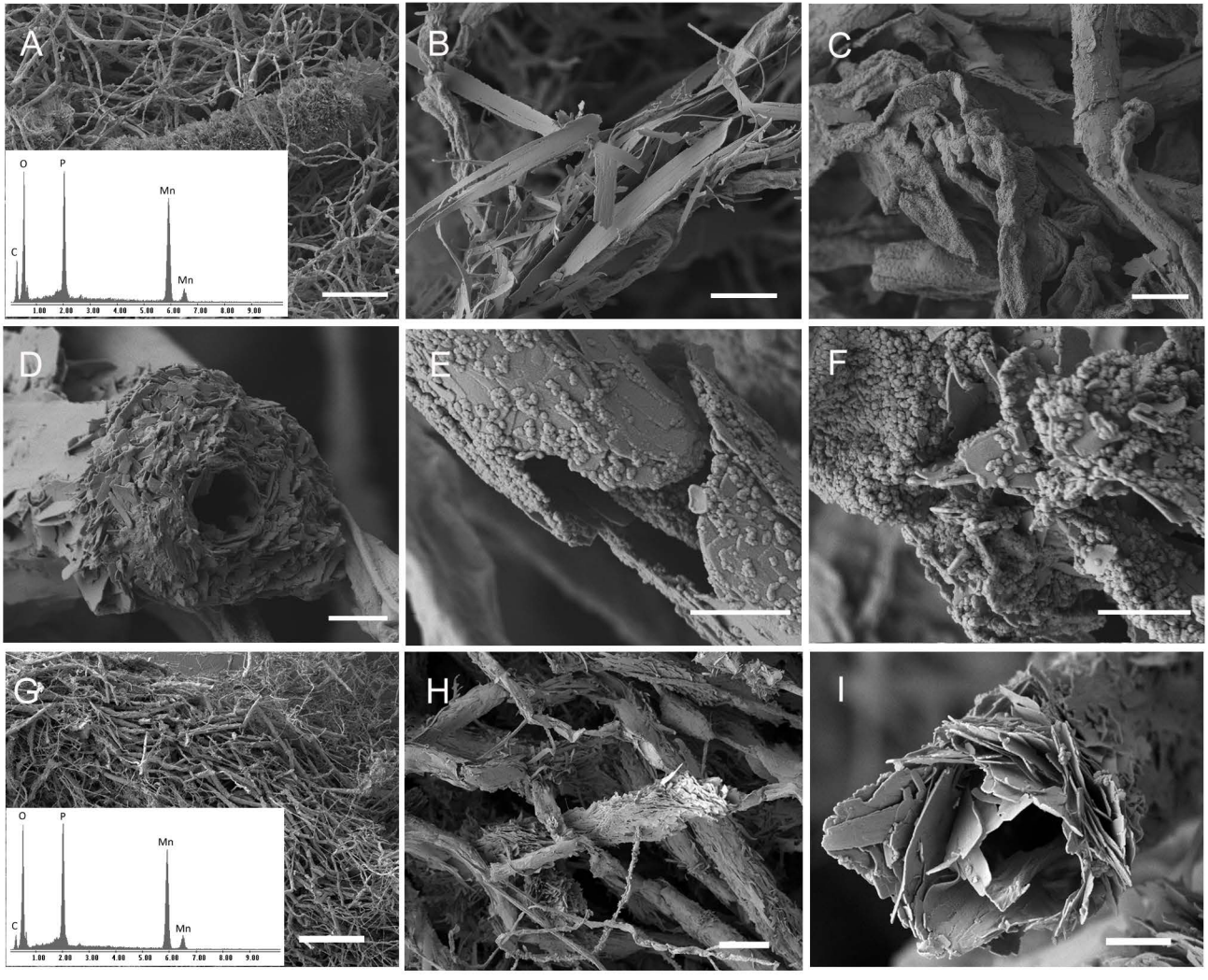
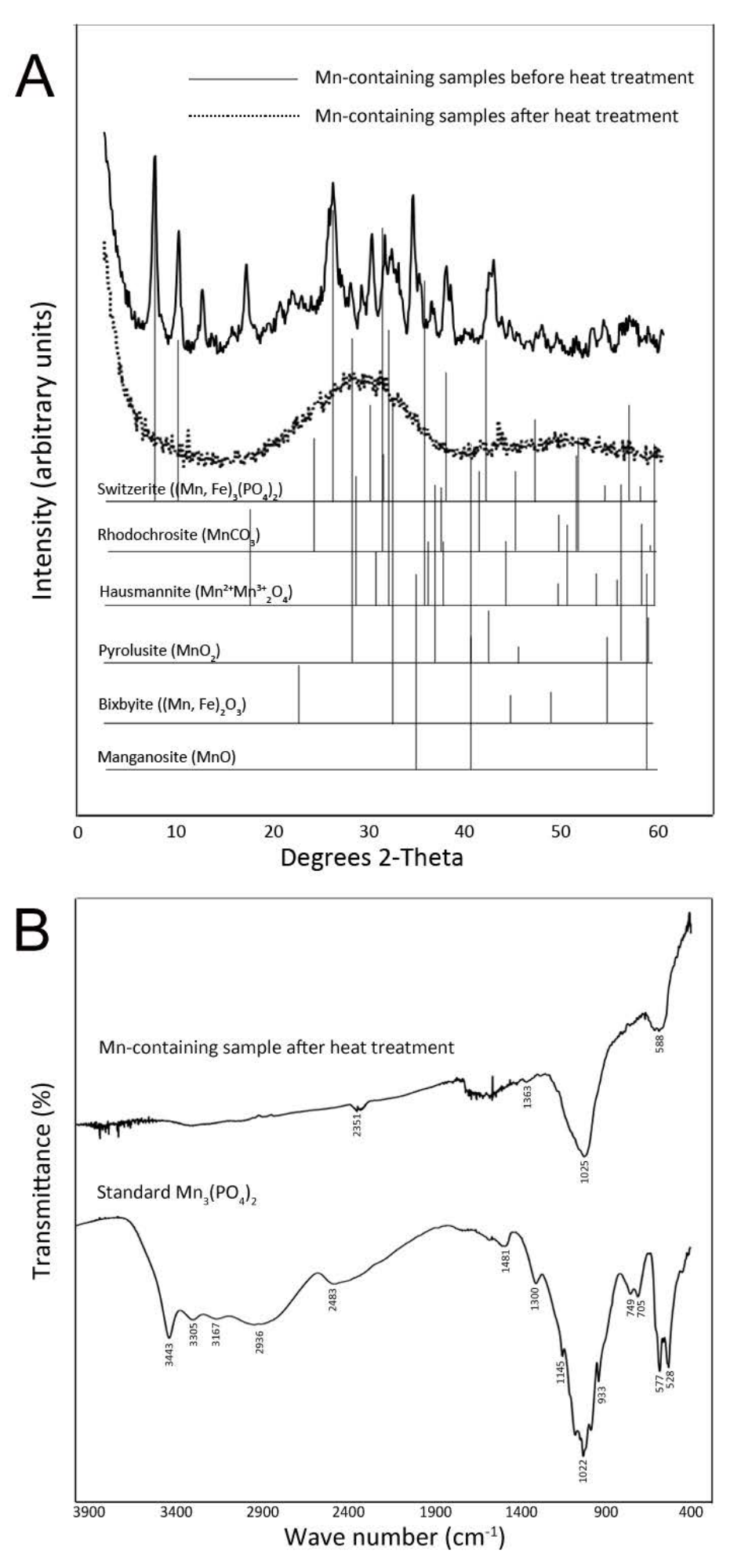
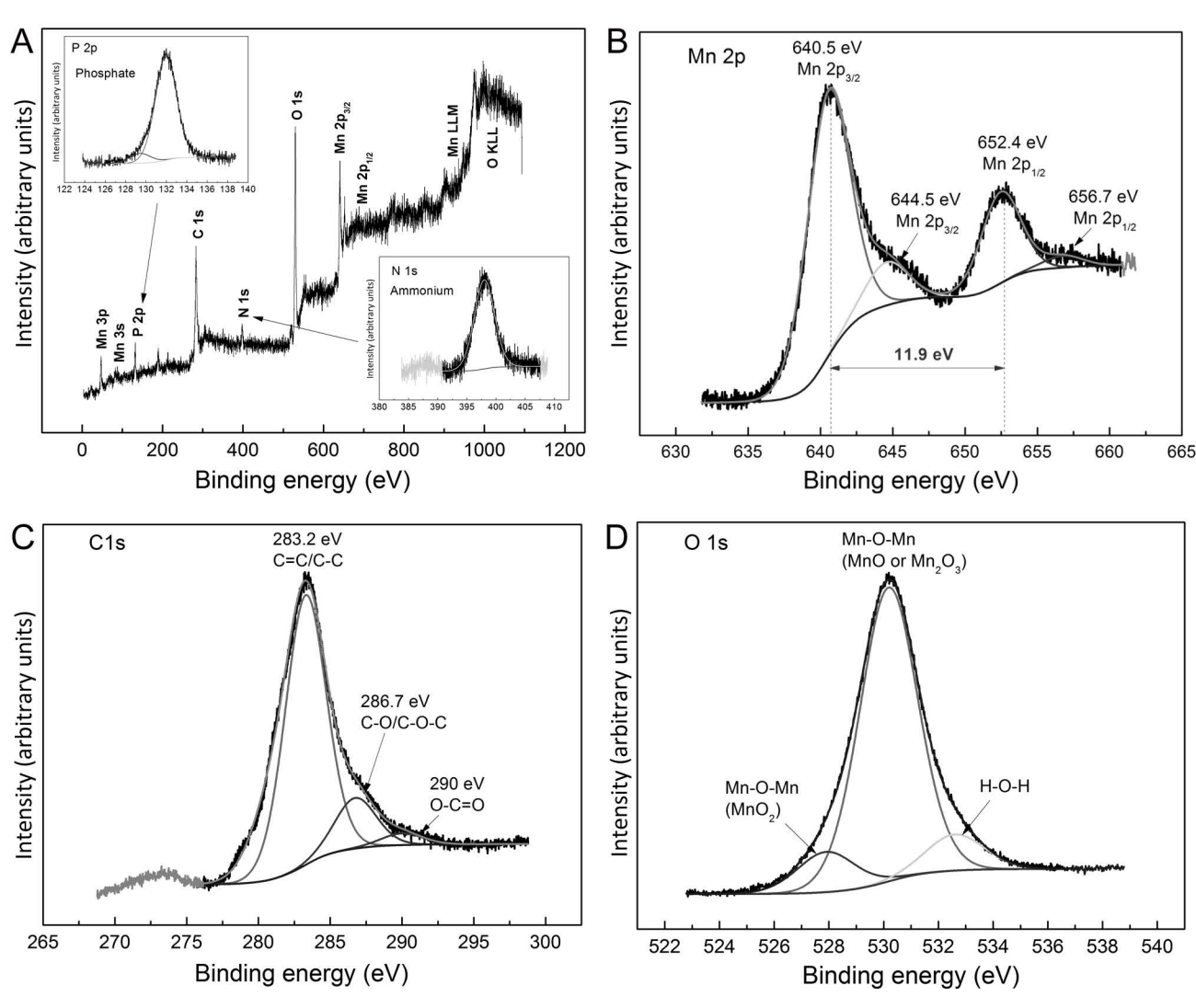
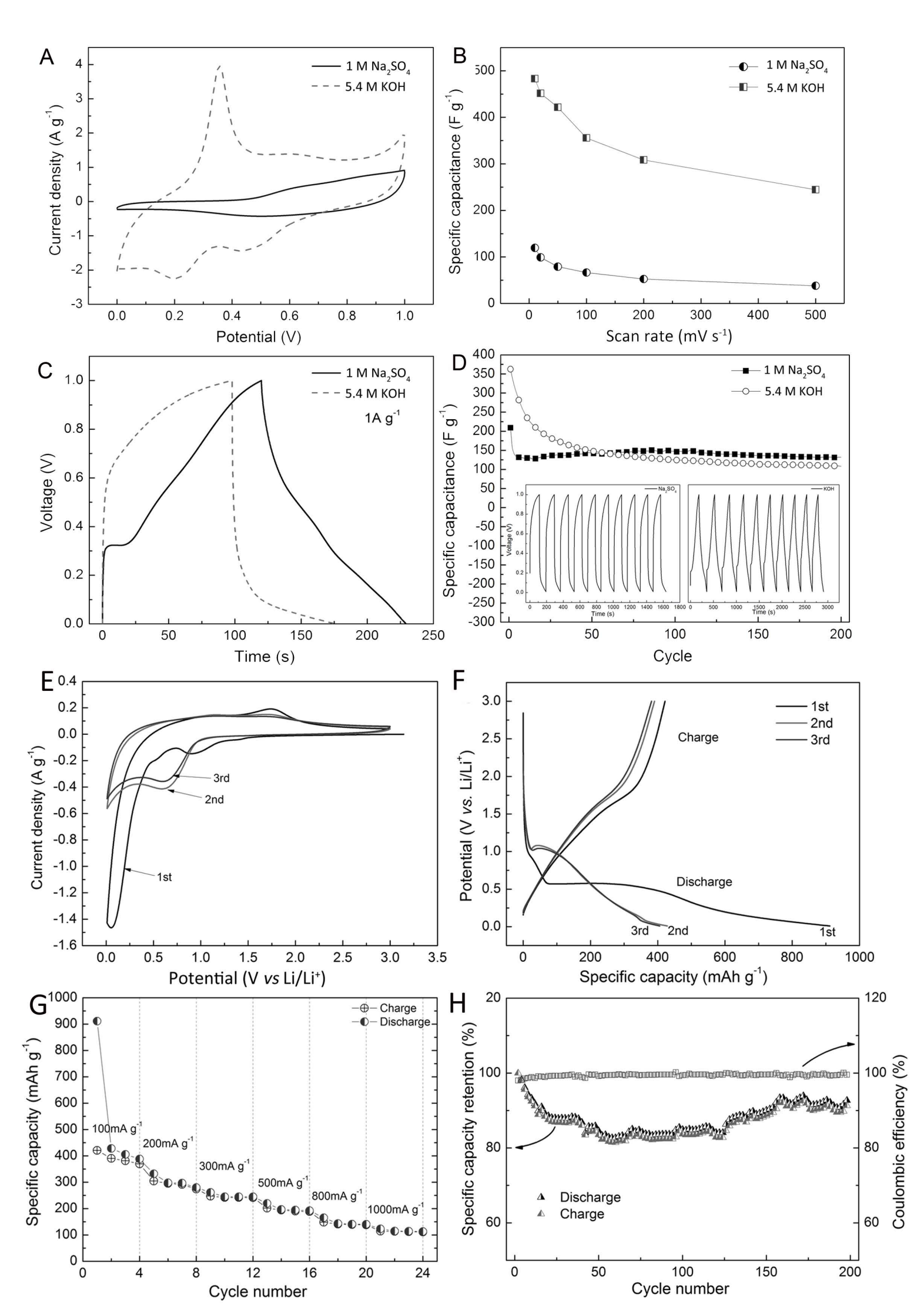

A
O
P
Mn
C
Mn
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00
B
C
D
E
F
G
O
P
Mn
C
Mn
1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00
H
I


A
Mn-containing samples before heat treatment
Mn-containing samples after heat treatment
Intensity (arbitrary units)
Switzerite ((Mn, Fe)3(PO4)2)
Rhodochrosite (MnCO3)
Hausmannite (Mn2+Mn3+2O4)
Pyrolusite (MnO2)
Bixbyite ((Mn, Fe)2O3)
Manganosite (MnO)
0
10
20
30
40
50
60
Degrees 2-Theta
B
Mn-containing sample after heat treatment
2351
1363
1025
588
Standard Mn3(PO4)2
3443
3305
3167
2936
2483
1481
1300
1145
1022
933
749
705
577
528
Transmittance (%)
3900
3400
2900
2400
1900
1400
900
400
Wave number (cm-1)


A
P 2p
Phosphate
Intensity (arbitrary units)
122 124 126 128 130 132 134 136 138 140
Mn 3p
Mn 3s
P 2p
C 1s
N 1s
O 1s
Mn 2p3/2
Mn 2p1/2
Mn LLM
O KLL
N 1s
Ammonium
Intensity (arbitrary units)
380 385 390 395 400 405 410
Intensity (arbitrary units)
0 200 400 600 800 1000 1200
Binding energy (eV)
B
Mn 2p
640.5 eV
Mn 2p3/2
652.4 eV
Mn 2p1/2
644.5 eV
Mn 2p3/2
656.7 eV
Mn 2p1/2
11.9 eV
Intensity (arbitrary units)
630 635 640 645 650 655 660 665
Binding energy (eV)
C
C1s
283.2 eV
C=C/C-C
286.7 eV
C-O/C-O-C
290 eV
O-C=O
Intensity (arbitrary units)
265 270 275 280 285 290 295 300
Binding energy (eV)
D
O 1s
Mn-O-Mn
(MnO or Mn2O3)
Mn-O-Mn
(MnO2)
H-O-H
Intensity (arbitrary units)
522 524 526 528 530 532 534 536 538 540
Binding energy (eV)


A
1 M Na2SO4
5.4 M KOH
Current density (A g-1)
Potential (V)
B
1 M Na2SO4
5.4 M KOH
Specific capacitance (F g-1)
Scan rate (mV s-1)
C
1 M Na2SO4
5.4 M KOH
1A g-1
Voltage (V)
Time (s)
D
1 M Na2SO4
5.4 M KOH
Specific capacitance (F g-1)
Cycle
Na2SO4
KOH
Voltage (V)
Time (s)
E
3rd
2nd
1st
Current density (A g-1)
Potential (V vs Li/Li+)
F
1st
2nd
3rd
Charge
Discharge
Potential (V vs. Li/Li+)
Specific capacity (mAh g-1)
G
Charge
Discharge
100mA g-1
200mA g-1
300mA g-1
500mA g-1
800mA g-1
1000mA g-1
Specific capacity (mAh g-1)
Cycle number
H
Discharge
Charge
Specific capacity retention (%)
Coulombic efficiency (%)
Cycle number